



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

March 22, 1999

Fire Fighter Dies as a Result of a Cardiac Arrest at the Scene of a Reported Structure Fire - Indiana

SUMMARY

On November 7, 1998, a 50-year-old male volunteer fire fighter responded in a Department tanker to the scene of a reported structural fire with smoke showing. Upon arrival at the scene, there was no fire or smoke, only steam emitting from a dryer vent. While other members of the department began completing the run report, the Captain (victim) collapsed in the cab of the tanker. Once removed from the cab, the victim was found to be unresponsive, without a pulse or respirations. Cardiopulmonary resuscitation (CPR) was initiated by on-scene fire fighters and was followed by advanced life support (ALS) administered by the responding ambulance service. Despite ALS measures administered for a total of 19 minutes on-site, during the 6-minute ambulance ride to the hospital, and for 13 minutes in the hospital's emergency department, the victim died. The death certificate listed ventricular fibrillation due to coronary artery disease as the cause of death. No autopsy was performed.

The victim had a previous history of coronary artery disease including coronary artery bypass surgery and coronary artery angioplasty. Four months prior to his death, the victim had an exercise stress test suggesting persistent ischemic heart disease. Despite this finding, the victim was released by his physician for volunteer fire fighting duties without restrictions.

The following recommendations address preventative measures that have been recommended by other agencies to reduce, among other things, the risk of on-duty heart attacks and cardiac arrests among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature, regulations

passed by enforcement agencies such as the Occupational Safety and Health Administration (OSHA), consensus votes of technical committees of the NFPA, or products of labor/management technical committees within the fire service. This preventative strategy consists of (1) minimizing physical stress on fire fighters; (2) screening to identify and subsequently rehabilitate high-risk individuals; and (3) encouraging increased individual physical capacity (fitness). Steps that could be taken to accomplish these ends include

- *Individuals with medical conditions that would present a significant risk to the safety and health of themselves or others should be precluded from fire fighting activities.*
- *Fire Fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.*
- *Follow provisions in the revised OSHA respiratory protection standard.*

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

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- *Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by offering a wellness/fitness program for fire fighters.*
- Fire Department policies and operating procedures
- Fire Department training records

- Fire Department annual report for 1997

- Past medical records of the deceased

- Death certificate of the deceased.

INTRODUCTION & METHODS

On November 7, 1998, a 50-year-old male Captain collapsed at the scene of a reported structural fire. Despite CPR and ALS administered by the fire fighters, emergency medical technicians/paramedics, and hospital emergency department personnel, the victim died on November 7, 1998. NIOSH was notified of this fatality on November 9, 1998, by the United States Fire Administration. On January 19, 1999, NIOSH telephoned the affected fire department to initiate the investigation. On February 9, 1999, Tommy Baldwin, a Safety and Occupational Health Specialist, and Thomas Hales, Senior Medical Officer, from the NIOSH Fire Fighter Fatality Investigation Team traveled to Indiana to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met with and interviewed the

- Fire Chief
- Fire Department personnel involved in this incident
- Family members
- Emergency medical technician/paramedic providing treatment

During the site visit NIOSH personnel also reviewed

- Fire Department Incident Report
- Existing Fire Department investigative records

INVESTIGATIVE RESULTS

Emergency Scene Response. On November 7, 1998, at 2033 hours, Central Dispatch notified the fire department of a structure fire with smoke showing at an apartment complex. Engine 8, staffed with three fire fighters, and Tanker 9, staffed with a Captain (the victim), were the first to respond and arrived at 2036 hours. Shortly thereafter additional equipment and fire department personnel arrived at the scene for a total of 6 vehicles (2 engines, 3 tankers, and 1 rescue vehicle) and 25 fire fighters.

Upon arrival at the scene, there was no fire or smoke, only steam emitting from a dryer vent. The Captain (victim), acting on orders from the Chief, remained in the Tanker while other fire fighters combed the scene for any sign of smoke or fire. The Chief notified Dispatch at 2040 hours to have incoming units respond under non-emergency conditions. At about 2045 hours, the Assistant Chief walked by Tanker 9 and spoke to the Captain (victim). At that time he was conversant and was not displaying any signs or symptoms of discomfort.

At 2046 hours, the investigation was completed and the scene was declared under control. At that time, the Assistant Chief noted the Captain (victim) was still sitting in the cab in no apparent distress. At 2048 hours, the Chief notified Dispatch that all units were clearing the scene. Engine 8, Tanker 9, and Tanker

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2, however, remained on-scene to complete the incident report. As the remainder of the units prepared to leave the scene, a fire fighter noted that the driver's door of Tanker 9 was open and inquired about who was driving the Tanker. As he prepared to climb into the cab, he saw the Captain (victim) slumped onto the floor.

The fire fighter immediately called for assistance from the Chief, Assistant Chief, and the remaining fire fighters. The victim was pulled out of the cab through the passenger door, laid on the ground and assessed for vital signs. At that time the victim was unresponsive, without a pulse or respirations. Cardiopulmonary resuscitation (CPR) was initiated while Dispatch was notified that a fire fighter was down. While at least one of the fire fighters remaining at the scene was trained and certified in advanced life support (ALS), none of the remaining department's vehicles were equipped with a heart monitor or a defibrillator.

At 2054 hours, Dispatch notified the County Emergency Medical Services (EMS), who arrived on-scene at 2057 hours. The victim was reassessed and, again, found to be unresponsive, without a pulse or respirations. While CPR was being maintained, a heart monitor found the victim's heart rhythm to be in ventricular fibrillation (V.Fib). Several shocks (electrical cardioversions) were delivered to the victim's chest without a change in his heart's rhythm. The victim was intubated, two peripheral intravenous lines were established and medications consistent with ALS protocols were given. CPR and ALS measures were continued for a total of 19 minutes on-site and during the 6 minute ambulance ride to the hospital.

In the hospital's emergency department, the victim was unconscious, pulseless, and without spontaneous respirations. The placement of the endotracheal tube was rechecked and found to be in the proper position. His initial heart rhythm was asystole and pulseless

electrical activity. ALS measures were continued for 13 minutes until 2135 hours, when he was pronounced dead.

Medical Findings. The death certificate was completed by the victim's personal physician. The immediate cause of death was listed as "ventricular fibrillation arrest," due to "coronary artery disease." No blood was sent for laboratory analysis, and, therefore, no carboxyhemoglobin levels, cardiac isoenzymes, or drug tests were available. No autopsy was performed.

In January 1998 the victim was diagnosed with two risk factors for coronary artery disease (CAD): high blood pressure (hypertension) and high blood cholesterol (hypercholesterolemia). Both these diseases were subsequently well-controlled with medication prescribed by his personal physician. In February 1998 the victim had a positive (abnormal) exercise stress test (EST), for which he underwent a cardiac catheterization, which showed "moderately severe" to "severe" CAD. He underwent coronary artery bypass surgery which was complicated by difficulty placing one of the grafts to his right coronary artery. After completing cardiac rehabilitation, the victim underwent another EST in June 1998. Although he improved his aerobic capacity and did not report symptoms of chest pain (angina), the nuclear imaging portion of the EST suggested a very large area of reduced blood supply (ischemia) in one area of the heart (inferolateral wall) and possible evidence of a new heart attack (infarction) in another area of the heart (apical wall). Cardiac catheterization revealed an occlusion of the graft to the right coronary artery at its origin and confirmed the ischemic and possible infarcted areas found during the EST. He underwent a successful scraping (percutaneous transluminal coronary atherectomy) and opening (angioplasty with double stent deployment) of his right coronary artery. Unfortunately, there was still some blockage



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("moderate residual narrowing") at the lower (distal) end of the right coronary artery based on a dye study performed immediately after the atherectomy and angioplasty procedure. Two weeks later, on July 1, 1998, the victim underwent a follow-up EST, during which he had no chest pain, no significant arrhythmias, and only non-specific and non-diagnostic ST segment changes in the anterolateral leads. Although the EST showed some improvement in the amount of ischemia, the imaging portion of the EST was still positive for "reversible segmental ischemia in the anterolateral left ventricular myocardium displayed in multiple planes."

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the fire department was comprised of 48 volunteers, in three stations, serving a population of approximately 3,500 in a geographic area of 33 square miles. In 1997, the department responded to 505 calls: 208 medical first response, 132 automobile accidents, 31 mutual aid, 28 grass fires, 28 false alarms, 20 structural fires, 20 vehicle fires, 13 carbon monoxide alarms, 9 unknowns, 8 unknown fires, 4 courtesy calls, 3 rekindles, and 1 bomb threat.

Training. The fire department provides all new fire fighters with the basic 24-hour recruit training required by the State of Indiana. The department also conducts 40 hours of additional on-the-job training each year. The victim had 16 years of fire fighting experience, was a certified Fire Fighter Second Class, served as the elected Chief of this Fire Department from 1985 to 1987, and was promoted to Captain in 1996.

Medical Clearance and Physical Fitness. Prior to joining the department, all volunteers must complete an application for membership. Two

questions are devoted to ascertaining medical history information:

"List any physical defects (including glasses, etc.)"

"Date of last physical [examination]"

Based on the applicant's response to these questions, the Department's Board of Directors can request additional information, or request additional medical evaluations. As a practical matter, over the past 10 years, the board has rarely requested additional medical evaluations, and no applicants have been denied membership for medical reasons. The department does not have a specific medical clearance evaluation for respirator use, nor do they have a physical agility/fitness requirement for new or current fire fighters. The department does require physician clearance for return to work following a leave of absence for medical reasons. On July 10, 1998, the victim's personal physician cleared him to return to "volunteer fire fighting duties with no restrictions."

DISCUSSION

Approximately 9 minutes after the victim's collapse, paramedics found the victim in ventricular fibrillation (V.Fib). V.Fib is the most common type of arrhythmia associated with cardiac arrest, occurring in 65-80% of all cardiac arrests.¹ In the United States, atherosclerotic coronary artery disease (CAD) is the most common risk factor for cardiac arrest and sudden cardiac death.¹ Risk factors for its development include increasing age, male gender, family history of CAD, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.² The victim had several of these risk factors, and had severe atherosclerotic lesions documented by cardiac catheterization.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years,

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typically decades.³ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁴ Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.⁵ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

Blood clots, or thrombus formation, in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.⁴ Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate (HR), increased catecholamines, and shear forces, which occur during heavy exercise.^{6,7} Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.⁸⁻¹¹

Fire fighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.¹²⁻¹⁴ The physiologic stress of responding to the fire department alarm, his underlying atherosclerotic CAD, with areas of myocardial ischemia documented by an EST test 5 months prior to this event, all contributed to this fire fighter's probable heart attack, subsequent cardiac arrest, and sudden death. The term "probable" is used because autopsy findings and/or blood tests (cardiac isoenzymes) are required to "confirm" a heart attack (myocardial infarction), and neither of these was performed.

Since the victim's coronary artery bypass surgery in February 1998, the victim did not report any episodes

of chest pain during physical activity performed at work, off-the-job, while performing duties as a volunteer fire fighter, or even during the July 1 EST which showed evidence of ischemia. This is somewhat surprising since chest pain (angina) typically accompanies ischemic heart disease. On the other hand, some individuals may not experience angina with ischemia, as evidenced by the finding that up to 20% of heart attacks are "silent" (i.e., painless).¹⁵

In 1997, the National Fire Protection Association (NFPA) updated Standard 1582, Medical Requirements for Fire Fighters.¹⁶ This voluntary industry standard specifies minimum medical requirements for candidates and current fire fighters. NFPA 1582 considers individuals with CAD (history of myocardial infarction, coronary artery bypass surgery, or coronary angioplasty) to be a "Category B Medical Condition." A Category B Medical Condition is defined as "a medical condition that, based on its severity or degree, **could** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others." Appendix A of the standard contains guidance for when to preclude a fire fighter with CAD from engaging in fire fighting activities. Appendix A states that "Persons at mildly increased risk for sudden incapacitation are acceptable for fire fighting. Mildly increased risk is defined by the presence of each of the following:

- Normal left ventricular ejection fraction
- Normal exercise tolerance, > 10 metabolic equivalents (METs)
- Absence of exercise-induced ischemia by exercise testing

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- Absence of exercise-induced complex ventricular arrhythmias
- Absence of hemodynamically significant stenosis on all major coronary arteries ($> \text{ or } = 70$ percent lumen diameter narrowing), or successful myocardial revascularization.”

Based on this fire fighter’s last EST in July 1998 and the dye studies performed immediately after his atherectomy and angioplasty in June 1998, he would not meet all of these criteria.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address preventative measures that have been recommended by other agencies to reduce, among other things, the risk of on-duty heart attacks and cardiac arrests among fire fighters. These recommendations have not been evaluated by NIOSH, but represent published research findings, regulations passed by enforcement agencies such as the Occupational Safety and Health Administration (OSHA), consensus votes of technical committees of the NFPA, or products of labor/management technical committees within the fire service. This preventative strategy consists of (1) minimizing physical stress on fire fighters; (2) screening to identify and subsequently rehabilitate high-risk individuals; and (3) encouraging increased individual physical capacity (fitness). Specific recommendations for this department include

Recommendation #1: Individuals with medical conditions that would present a significant risk to the safety and health of themselves or others should be precluded from fire fighting activities.

The NFPA Standard 1582, Medical Requirements for Fire Fighters, lists medical conditions that **should** (Category A) or **could** preclude (Category B) individuals from performing fire fighter activities.¹⁶

We recommend fire departments adopt these recommendations and share this standard (NFPA 1582) with physicians responsible for these decisions.

Recommendation #2: Fire Fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of periodic medical evaluations for fire fighters can be found in NFPA Standard 1582, Medical Requirements for Fire Fighters¹⁶, and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs wellness/fitness initiative.¹⁷

Recommendation #3: Follow provisions in the revised OSHA respiratory protection standard.

Indiana operates an OSHA-approved State plan. Therefore public employees in Indiana, including fire fighters, are required to comply with all OSHA standards. The Indiana Department of Labor considers volunteer fire fighters to be “employees” and their fire departments “employers” for occupational safety and health regulatory purposes. One OSHA standard applicable to all fire departments is the respiratory protection standard.¹⁸ This standard, also known as the 2-in/2-out rule, requires employees working in “atmospheres that are immediately dangerous to life or health,” which includes structural fire fighting, to work in a double buddy system. This double buddy system is designed to protect fire fighters while conducting interior structural fire fighting operations. While this department’s policies are consistent with the 2-in/2-out portion of the standard, other provisions need attention, specifically, a written respiratory protection program and a medical evaluation for fire fighters wearing SCBA.

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Recommendation #4: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by offering a wellness/fitness program for fire fighters.

NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.¹⁹ In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs joined in a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual with a video detailing elements of such a program.¹⁷ Fire departments should review these materials to identify elements applicable to their department.

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